Volume 31 August, 1945 *Number 8*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

GREASES
Part II
Their Characteristics
and Uses

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

Precautions in Handling Greases

1. Store all grease in a cool dry place.
   Heat increases the rate of oxidation of greases. Even greases inhibited against oxidation can deteriorate if stored in the sunlight or next to hot steam pipes for a long period of time.
2. Keep all containers covered.
   There are several very good reasons why grease containers should be kept covered. The most obvious, of course, is to keep the grease from becoming contaminated with dirt. A second one is that both air and light have a tendency to increase the rate of oxidation of greases. If tightly covered containers are stored in a cool dry place, the grease in such containers will not oxidize appreciably even after comparatively long periods of time.
3. Use the oldest grease first.
4. Wipe off the edges of the container before opening each time.
5. Use clean spatulas or wooden paddles which will not splinter when removing grease from containers.
6. Be sure to clean all fittings and equipment used before applying grease to bearings, thus avoiding contamination of the grease.
7. Anti-friction bearings should not only be clean but dry before applying grease.
   A film or coating of oil may prevent proper adhesion of the grease to bearing surfaces. Great care should also be exercised to prevent the possibility of perspiration from fingers or hands causing rusting of metallic surfaces.

For Satisfactory Grease Lubrication, Use Greases of Good Quality and Keep Them Clean.

THE TEXAS COMPANY

LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

Published by
The Texas Company, 135 East 42nd Street, New York 17, N. Y.
Copyright 1945 by The Texas Company

Vol. XXXI August, 1945 No. 8

Change of Address: In reporting change of address kindly give both old and new addresses.
"The contents of 'LUBRICATION' are copyrighted and cannot be reprinted by other publications without written approval and then only provided the article is quoted exactly and credit given to THE TEXAS COMPANY."

GREASES

Part II — Their Characteristics and Uses*

GREASES, without reservation, can be said to be one of the major contributions to the present high degree of efficiency and simplicity in design of modern machinery.

Without greases, housings of bearings normally grease lubricated would have to be made oil tight; seals would have to be improved to preclude ingress of dust and dirt; inaccessable grease lubricated bearings would have to be made available either for hand oiling or by use of oil lines; bearings would have to be lubricated at more frequent intervals; and the dripping or spattering of oil would impair appearances and possibly contaminate material being handled on certain types of machines.

The machinery of years ago could be lubricated satisfactorily with comparatively few and simple greases. The demands of modern machinery, however, are so exacting that today many grease manufacturers supply well over a hundred products to fulfill the many individual requirements.

With the exception of a comparatively few specialty products most of the greases on the market today are fundamentally of seven types, and the general properties of all greases falling within a given group are somewhat similar. The characteristics of each group are sufficiently different so that it is comparatively easy to select the correct type or group of greases which should be used on a specific application. Which of the individual members of a group should then be used depends upon the type of service and such factors as the viscosity of the oil component desired, quality of the grease, economics, method of application and similar considerations.

The ensuing discussion of the general characteristics of greases and properties of each group is presented in the hope that this information will be of assistance to those charged with the application or purchasing of greases.

GREASES are an intimate dispersion of soap and oil resulting from the application of heat and agitation. The properties of greases are primarily dictated by the type of metallic base used in the soap. These properties are further modified by the type of fatty material saponified with the metallic base, and the oil used. The great majority of the greases on the market today are of seven types, classified on the basis of the metallic base used and to a limited extent on their method of manufacture. These are:

1. **Calcium soap base or cup grease.**
2. **Calcium resinate soap base or axle grease.**
3. **Sodium soap base — general.**
4. **Sodium soap base — brick grease.**
5. **Aluminum soap base grease.**
6. **Lithium soap base grease.**
7. **Mixed base greases.**

A knowledge of the properties and limitations of these seven types is an aid in determining what particular grease is best suited for a specific application, and why.

*Part I, "Greases — Their Manufacture" was presented in the May issue of LUBRICATION.

Figure 1—ASTM Penetrometer and grease worker.

GENERAL PROPERTIES OF GREASES

The most important single property of a grease is that it is plastic or a semi-solid material. This property permits greases to be used in a wide variety of applications not normally suited for oil lubrication.

Soap, the plasticizer used in greases not only serves as a "thickener" but contributes materially to the properties of the final grease. Such factors as texture, appearance and other physical properties are to a great extent dependent upon the type of soap used.

The two most widely used types of soaps today are those made from calcium and sodium bases. Greases incorporating the former are usually smooth textured, water resistant and are often termed Cup greases. The sodium base greases are normally fibrous but can be made smooth in texture, are somewhat more water susceptible, and are heat resistant. Properties of these types and others are given in detail later.

Consistency of Greases

Greases normally vary in body from soap thickened oil which may be fluid at room temperature to brick type greases so hard that they must be cut with a wire or knife. The term "consistency" is usually used to describe this property of greases.

Consistency may be defined as a measure of the relative resistance of a grease to permanent change in shape, or in simpler words, consistency is a numerical measure of the hardness of a grease. It is used to classify greases in the same manner as viscosity is used to classify oils.

Many methods have been developed to test this property in greases but the most commonly accepted one is the ASTM* penetration test, illustrated in Figure 1, Page 80. In this method the depth (measured in 1/10 mm) to which a cone of standard shape and weight penetrates a grease in 5 seconds at 77°F. is termed the penetration of that grease.

The consistency of a grease is dependent to a great extent on the amount of soap it contains, although other factors such as the type of fatty material and oil incorporated in it, method of manufacture, the final water content, the temperature of the grease when put in shipping containers, and working, all influence its consistency.

Most greases on working tend to become softer. In fact, one of the major problems confronting grease technologists for years was the matter of developing greases which would be resistant to thinning down. Modern research has developed lubricating greases which show negligible thinning and has resulted in marked improvement in performance of such greases, particularly where considerable working is experienced, (for example, in ball and roller bearings, gear boxes, etc.) in that leakage is no longer a factor to contend with in the sense that it was years ago.

The ASTM penetration determined on greases in original containers, or removed from their containers with a minimum of working is termed the "Unworked Penetration." In view of the tendency for greases to change somewhat in unworked consistency on standing and in order to insure better reproducibility of results when determining penetrations of greases, the ASTM has developed a worker which consists of a closed cup in which the grease is placed and a perforated disk plunger. To work a grease the plunger is forced through the grease up and down for 60 full double strokes. The worked grease is brought to a temperature of 77° F. ± 30, and its penetration determined. This value is termed the "Worked Penetration." The difference between the worked and unworked penetration should not be used as an indication of the tendency of the grease to become thinner in use since many greases which show no "working down" by the ASTM 60 stroke test may become very thin in use. The more recent development of greases which show practically no working down in service has led to the use of 100,000 workings in the ASTM test rather than the present 60 workings.

Greases, with the exception of very hard ones, are being worked from the time they are removed from the container until applied to a bearing, and while the bearing is in operation. Therefore, one is usually most interested in the consistency of a specific grease during its service. For this reason the penetration of softer grades of greases is usually reported on a worked basis. The unworked penetration of greases

*American Society for Testing Materials.

ERRATA

August, 1945 issue of magazine "Lubrication," "Greases, Part II — Their Characteristics and Uses."

On Page 80, column two, fourth paragraph, appears the following statement:

> "The worked grease is brought to a temperature of 77° F. ± 30, . . ."

This temperature should be "77° F. ± 3.0."

Figure 1—ASTM Penetrometer and grease worker.

GENERAL PROPERTIES OF GREASES

The most important single property of a grease is that it is plastic or a semi-solid material. This property permits greases to be used in a wide variety of applications not normally suited for oil lubrication.

Soap, the plasticizer used in greases not only serves as a "thickener" but contributes materially to the properties of the final grease. Such factors as texture, appearance and other physical properties are to a great extent dependent upon the type of soap used.

The two most widely used types of soaps today are those made from calcium and sodium bases. Greases incorporating the former are usually smooth textured, water resistant and are often termed Cup greases. The sodium base greases are normally fibrous but can be made smooth in texture, are somewhat more water susceptible, and are heat resistant. Properties of these types and others are given in detail later.

Consistency of Greases

Greases normally vary in body from soap thickened oil which may be fluid at room temperature to brick type greases so hard that they must be cut with a wire or knife. The term "consistency" is usually used to describe this property of greases.

Consistency may be defined as a measure of the relative resistance of a grease to permanent change in shape, or in simpler words, consistency is a numerical measure of the hardness of a grease. It is used to classify greases in the same manner as viscosity is used to classify oils.

Many methods have been developed to test this property in greases but the most commonly accepted one is the ASTM* penetration test, illustrated in Figure 1, Page 80. In this method the depth (measured in 1/10 mm) to which a cone of standard shape and weight penetrates a grease in 5 seconds at 77°F. is termed the penetration of that grease.

The consistency of a grease is dependent to a great extent on the amount of soap it contains, although other factors such as the type of fatty material and oil incorporated in it, method of manufacture, the final water content, the temperature of the grease when put in shipping containers, and working, all influence its consistency.

Most greases on working tend to become softer. In fact, one of the major problems confronting grease technologists for years was the matter of developing greases which would be resistant to thinning down. Modern research has developed lubricating greases which show negligible thinning and has resulted in marked improvement in performance of such greases, particularly where considerable working is experienced, (for example, in ball and roller bearings, gear boxes, etc.) in that leakage is no longer a factor to contend with in the sense that it was years ago.

The ASTM penetration determined on greases in original containers, or removed from their containers with a minimum of working is termed the "Unworked Penetration." In view of the tendency for greases to change somewhat in unworked consistency on standing and in order to insure better reproducibility of results when determining penetrations of greases, the ASTM has developed a worker which consists of a closed cup in which the grease is placed and a perforated disk plunger. To work a grease the plunger is forced through the grease up and down for 60 full double strokes. The worked grease is brought to a temperature of 77° F. ± 30, and its penetration determined. This value is termed the "Worked Penetration." The difference between the worked and unworked penetration should not be used as an indication of the tendency of the grease to become thinner in use since many greases which show no "working down" by the ASTM 60 stroke test may become very thin in use. The more recent development of greases which show practically no working down in service has led to the use of 100,000 workings in the ASTM test rather than the present 60 workings.

Greases, with the exception of very hard ones, are being worked from the time they are removed from the container until applied to a bearing, and while the bearing is in operation. Therefore, one is usually most interested in the consistency of a specific grease during its service. For this reason the penetration of softer grades of greases is usually reported on a worked basis. The unworked penetration of greases

*American Society for Testing Materials.

is valuable for use as a control test during manufacture and for determining the consistency of hard greases, particularly the brick type, which cannot be easily worked.

The National Lubricating Grease Institute has developed a classification system for unctuous greases, which is generally accepted by both manufacturers and consumers today. This system is based on the worked penetration because, as explained above, the worked penetration is generally more significant than the unworked penetration for greases covered by this classification.

N.L.G.I. Classification

N.L.G.I. Number	ASTM Worked Penetration
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

It will be seen that the NLGI classification only allows a thirty-point range in the ASTM penetration for each grade. This is a very narrow range since ASTM Method D-217-44T allows a mean deviation of 3 per cent, and reproducibility between laboratories is necessarily even poorer.

The narrow limits chosen would appear to assign an importance to penetration far out of proportion to the actual significance of this test which points to the desirability of broadening these limits and reducing the number of grades under the NLGI classification.

A nomenclature for lighter greases commonly termed "semi-fluid" has been proposed but not generally accepted as yet. A numbering system for heavier greases, such as brick greases, has never been standardized and the choice of a suitable system is left entirely to individual suppliers.

Chemical Stability of Greases in Storage and Use

In general, well made lubricating greases possess sufficient oxidation stability under ordinary conditions. However, where severe oxidizing conditions are anticipated, inhibited greases are necessary.

The oxidation of greases, promoted by heat, light and air occurs in two stages as indicated by results obtained on static oxidation tests. (See Figure 2 Page 81 for a description of the Norma Hoffman Oxidation Test.) The first is termed the "induction period" during which a comparatively slow reaction rate occurs. Ultimately there is a definite increase in the reaction rate and it is during this second phase that the grease will quickly darken, may turn rancid, perhaps separate oil, and show a decided increase in the percentage of decomposition products in the grease.

The accelerated oxidation test method described above is a static test, inasmuch as the grease surface rather than the entire mass of the grease is subjected to oxidation. This is, of course, a condition similar to that to which a grease is subjected in storage, but is not the condition existing in actual usage. Grease research chemists have sought for an accelerated oxidation test method which would be dynamic; that is, the entire mass of the grease would be subjected to oxidation, but this has been complicated by the fact that a grease is not fluid and oxygen cannot be blown through it as is the case with a mineral oil. Recently an accelerated dynamic oxidation test method has been developed whereby fresh surfaces of the grease are continuously exposed to oxidation by passing the grease back and forth through tiny orifices into an atmosphere of oxygen under controlled conditions of temperature and pressure. Such a test is illustrated in Figure 3, Page 82.

The type of decomposition products formed as a

Figure 2—Norma Hoffman Oxidation Test. An accelerated static oxidation test in which grease is placed in the glass trays, the assembled bomb in a bath at controlled temperatures, and the rate at which oxygen is absorbed in the grease is measured by noting the pressure drop on the gage.

result of oxidation depend upon the ingredients used and the conditions of oxidation; for example, a grease oxidized as a result of long time storage may not contain the same type of decomposition products as it would if it became oxidized as a result of operation on a high temperature anti-friction bearing.

In the laboratory the degree of decomposition of a grease due to oxidation is usually measured by the percent of free fatty acid formed. Although other types of products are undoubtedly formed to some extent it would be very difficult to analyze these, particularly in routine work. Some fatty acids formed may, under certain conditions, be somewhat corrosive but in most instances they are not. Badly oxidized greases in actual service have been found to contain as high as six percent free fatty acids (calculated as oleic acid) yet the bearings showed no sign of corrosion.

The foregoing discussion on the oxidation of greases has some very practical applications. For example, it explains why greases should never be stored for an extended period of time, near hot steam lines or in the sun. Any grease which, after a long period of storage has changed color throughout most of its mass and has developed a highly rancid smell should be used with caution or discarded.

Greases left in uncovered or loosely covered containers often show discoloration of their exposed surfaces upon ageing and ingress of dirt. Such material should be scraped off and discarded for the presence of dirt can do considerable harm to some bearings and this grease already partially oxidized will not stand up in service as long as the fresh grease underneath.

Oil Bleeding

"Separation of free oil from grease, commonly called bleeding, has long been a source of controversy although a limited amount of oil bleeding is not harmful in the great majority of applications and in some cases may even be desirable. Consumers tend to demand bleed-free greases and numerous specifications have itemized test methods to achieve this end."[1]

"All lubricating greases should sweat a little free oil to enable them to creep into narrow clearances by capillary action. All satisfactory greases now in service do sweat a little oil. It is not correct to assume that the grease which passes the most severe sweating test will give the best lubrication."[2]

It is easily understandable why consumers who are not thoroughly familiar with the intricate details of grease manufacture and the theories of lubrication would, on first thought, prefer a grease which shows no oil bleeding in storage since this conclusion would naturally be based on appearance. Actually, as indicated above, some unobjectionable oil separation in storage is a natural characteristic of lubricating greases and has distinctive advantages.

Dropping Point of Greases

The application of heat to greases causes them to soften gradually and the temperature at which a grease passes from a semi-solid to a so-called liquid state is difficult to define clearly. Many methods have been devoleped to determine this point and the

[1]The Institute Spokesman published by the National Lubricating Grease Institute. Vol VII, No. 6, Pg. 2, Sept., 1943.
[2]The Institute Spokesman, published by the National Lubricating Grease Institute, Vol. VIII, No. 2, Pg. 5, May, 1944.

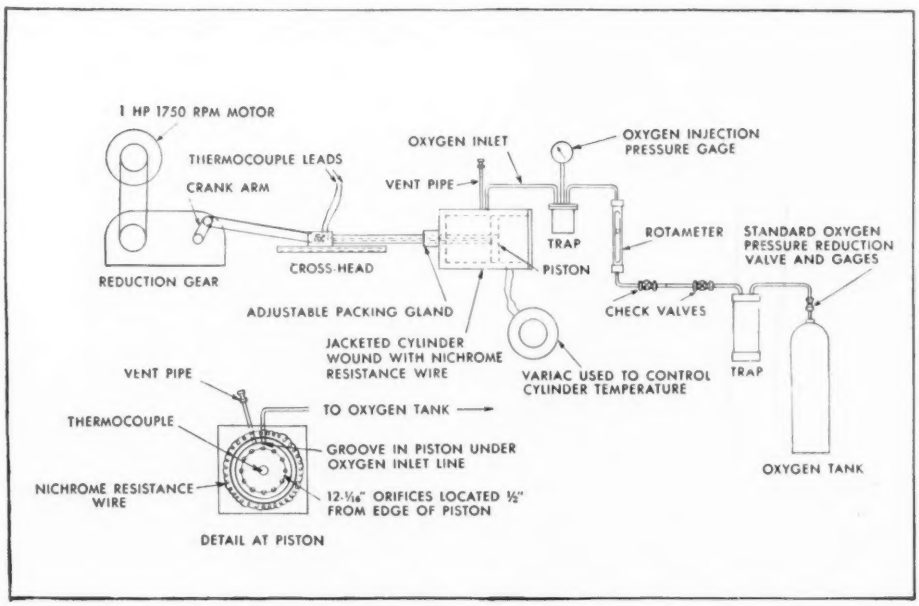


Figure 3—Dynamic Oxidation Test developed by The Texas Company.

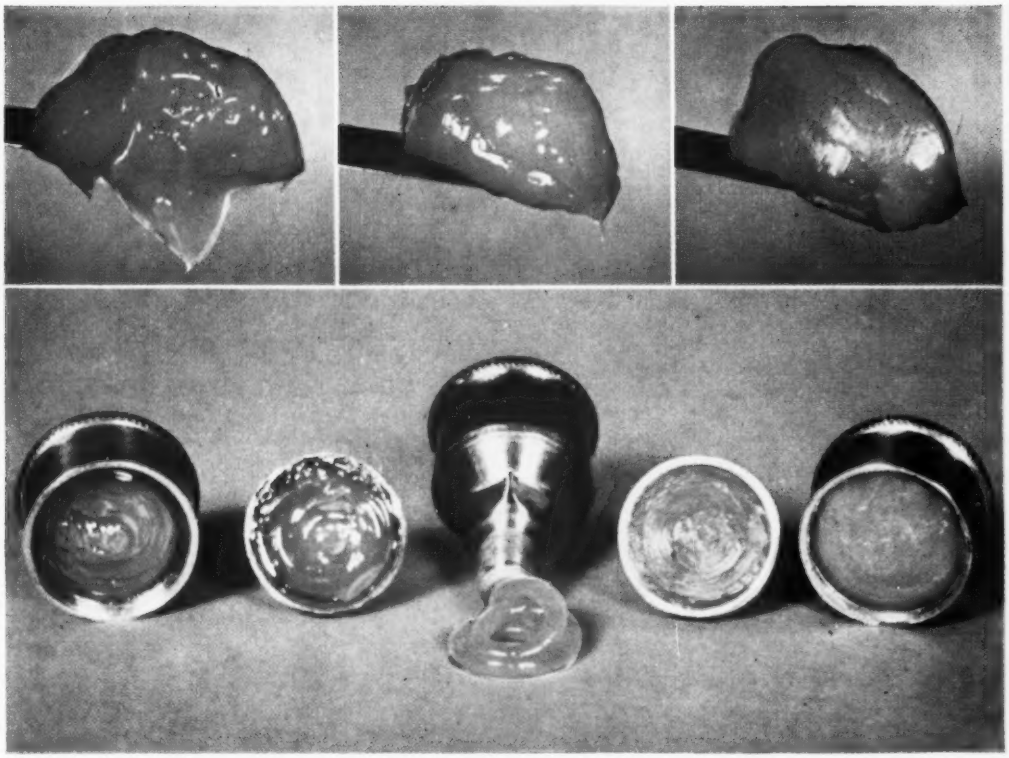


Figure 4—Group No. 1—Calcium soap base or cup greases. The above greases incorporate an oil having an approximate viscosity of 300 seconds at 100°F. Say. Univ. NLGI Grade No. 1 is represented at the left, No. 3 in the middle, and No. 5 at the right.

values obtained vary widely depending upon the method used. More recently the ASTM has standardized on what is now termed the dropping point of greases. Briefly, the dropping point can be defined as the temperature at which a drop of grease disengages itself from the remainder. In the ASTM test (Method D-566-42) the temperature of a grease sample contained in a cup is raised at a standard rate and when the grease has become sufficiently fluid so that one drop falls through a hole in the bottom of the cup, the temperature is noted and this temperature is termed the dropping point of the grease.

Since semi-fluid greases extrude from the cup at room temperature, this test is not applicable nor is there a standard method for determining the dropping point of such greases.

The dropping point of a grease is no criterion of the maximum temperature at which it can be used. For example: ordinary cup greases in which the oil and soap are held together or stabilized by means of water have dropping points in the order of 200-225°F., yet in many cases they cannot operate continuously at temperatures above about 175°F. since continued subjection to heat at even this lower temperature causes vaporization of the water and eventually break-down of the grease into soap and oil.

Conversely, some greases may be used for short periods of time even above their dropping points but in such cases the housing must be such as to prevent leakage of the fluid grease. At best, therefore, the dropping point of a grease should be used primarily as an indication of uniformity of manufacture and as a means of identifying greases. The best way to determine the potential high temperature performance of a grease is to test it in the laboratory under simulated field conditions or by conducting actual tests in the field.

Oil Component

In general, greases can be made incorporating all types of oils ranging in viscosity from light spindle oils to cylinder oils. Whether the oil used is naphthenic or paraffinic in nature depends upon the general type of service in which the grease is to be used, cost of final product, and in some instances, one or the other may produce a superior grease from a texture standpoint.

The quality of an oil used in a grease is dependent upon the service to which the grease is to be put, and the economics involved. Greases used in applications relubricated at infrequent intervals, and in installa-

GENERAL CHARACTERISTICS OF GREASES

GROUP NO.	1	2	3	4	5	6	7
SOAP BASE	CALCIUM-GENERAL	CALCIUM RESINATE	SODIUM GENERAL	SODIUM BRICK TYPE	ALUMINUM	LITHIUM	MIXED BASE SODIUM-CALCIUM
TEXTURE	Buttery	Buttery	Fibrous or Smooth	Hard-Brittle	Some Buttery Some Stringy but never fibrous	Buttery to Stringy	Fairly Buttery to fibrous
DROPPING POINT (Approx.)	200-225°F.	275°F.	300-450°F.	300-450°F.	200°F.	400°F.	315°F
CONDITION AFTER HEATING ABOVE MELTING POINT & COOLING	Separates (See remarks below)	Foams at 200°F. Separates on prolonged heating.	No change if worked	No change	Changes texture upon cooling but does not separate above melting point or below.	No change if worked	No change if worked
MAXIMUM CONTINUOUS USEABLE TEMPERATURE	175°F.	200°F.	300-400°F.	300-450°F.	200°F. (See remarks below)	300°F.	300°F.
EFFECT OF WATER	Resistant	Resistant	Susceptible	Susceptible	Resistant	Resistant	Susceptible
RESISTANCE TO SOFTENING UPON WORKING	Fair to Poor	Fair to Poor	Excellent to Poor (Varies greatly with composition)	Fair to Poor (Varies greatly with composition)	Fair to Poor	Excellent to Poor (Varies greatly with composition)	Excellent to Poor (Varies greatly with composition)
PRIMARY USE	General purpose industrial lubricant for plain bearing and line shafting.	Rough heavy bearings operating at slow speeds, also skids, track curves, and wagon wheels.	Ball and roller bearings operating at low to medium speeds, and light to heavy loads; also on wheel bearings and chassis of automobiles and trucks	Driving journals of locomotives and similar bearings lubricated with brick greases.	Special applications where resistance to centrifugal force or adhesiveness is desired.	Aircraft lubrication at temperatures down to −100°F.	All types ball and roller bearings, and special applications at both high and low temperatures depending upon make up.
REMARKS	Certain greases stabilized with high boiling chemicals instead of water have higher dropping points and can be used to higher maximum temperatures. They return to a homogeneous state upon cooling after being melted.	Usually used where cheapness is major factor.	Water susceptibility probably greatest limitation, but offers rust protection. Short fibred or smooth textured greases used on anti-friction bearings, while long fibred greases recommended for chassis lubrication.	Usually applied directly against revolving journal.	These greases change texture upon heating and upon cooling. Therefore, they are not recommended for use above 150°F.	Offer great promise as general purpose greases.	Mixed base greases are a combination of two or more types of greases. The most outstanding example is sodium-calcium soap base greases, properties of which resemble characteristics of major component.

tions where heat resistance is a prime consideration, should incorporate well refined oils which are resistant to oxidation. In instances where such high quality products are not necessary greases used may contain oils which are less expensive to manufacture.

The assumption has often been made that the grease applied to a specific application should contain an oil having approximately the same viscosity as would an oil if the bearing were oil lubricated. This is not necessarily true since it has been found in many cases that a lighter oil can be used. For example, ball or roller bearings under six inches in diameter, operating at 1000-2000 RPM and at 200°F. are normally lubricated with an oil having a viscosity of 500 to 800 seconds Saybolt Universal at 100°F. whereas a good ball and roller bearing grease for the same applications will contain an oil having a viscosity of only 150 to 300 seconds at 100°F. In reality, this means that all other factors being equal, a grease film will support a somewhat heavier load than will an oil film.

PROPERTIES OF VARIOUS TYPES OF GREASES

Most greases in use today can be classified in seven groups, based on the metallic base incorporated in them and to a limited extent on their method of manufacture. The ensuing discussion of the properties of these groups is sufficiently general to include the majority of greases on the market today. However, special greases can be made which, particularly in appearance and texture, do not resemble the majority of similar greases falling within the same group. Most sodium soap base greases, for example, are somewhat fibrous but some can be made with a buttery texture. Normally these exceptions are designed with a particular objective in mind and the merits of such greases can best be explained by their manufacturer.

In reading the following discussion of the various properties of greases, it must be borne in mind that all greases within a given group can not necessarily be utilized to obtain full advantage of all properties listed, because of other possible limiting factors. For example, consider ultra-low temperature greases made from a high melting point soap. Such greases usually incorporate a very light oil (viscosity of 40-60 seconds at 100°F. Say. Univ.) some of which will evaporate at temperatures above 150°F. Even though the grease may have a dropping point of about 350°F. it is obvious that the practical application of such greases is limited to a maximum continuous operating temperature of approximately 150°F. due to the high volatility of the mineral oil.

Group No. 1—Calcium Soap Base or Cup Grease

Calcium soap is one of the most popular soap bases used in greases today. These products, often termed cup greases, are widely used in industrial plants as a general lubricant for they offer economical lubrication on plain bearings, line shafting, sliding surfaces, and lightly loaded ball bearings revolving at low speeds.

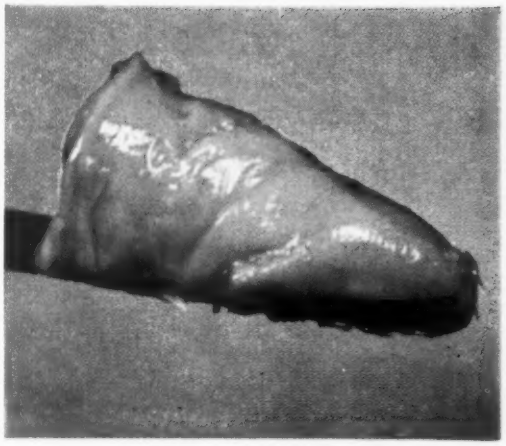


Figure 5—Group No. 2—Calcium resinate soap base or axle grease made with pale oil.

Cup greases have a very pleasing appearance. Their texture is usually smooth and buttery although they can be made somewhat tacky by suitable choice of ingredients. Softer grades normally have a very glossy appearance while the heavier grades are somewhat duller.

One of the outstanding properties of this group of greases is that they are water resistant. In fact, they have been used to lubricate bearings operating in water. As a result calcium soap base greases are widely used in applications where the grease is likely to be contaminated with water, for example, water pumps and the wet end of paper machines.

Most cup greases consist of oil and soap held together, or stabilized with water. Even though these greases have a dropping point of approximately 200-225°F. they cannot be used continuously at temperatures above about 175°F. due to water evaporation. However, as a result of research work done in the last few years, calcium soap base greases have been developed in which high boiling point materials displace the water as stabilizers. The newer greases not only can be used at higher temperatures than water stabilized greases because of the absence of water, but they have higher dropping points and can be heated above their dropping points without danger of separation.

Most cup greases on the market today contain oils having a viscosity of 200 to 500 seconds at 100°F. (Say. Univ.). Such products are normally used as a general lubricant throughout plants. Heavier oils having a viscosity of 700-2000 seconds at 100°F.

and over are sometimes incorporated in calcium soap base greases for use in applications of a heavy duty type where temperatures are not high and where water contamination is a factor to contend with.

Group No. 2—Calcium Resinate Soap Base or Axle Grease

Calcium resinate soap base greases are usually used where, due to the nature of operating conditions, it is necessary to use an excessive amount of grease to prevent dust and other foreign matters from entering bearings. Because cheapness has been considered a prime factor in such cases, these greases are often made with oils which are not too highly refined. Typical uses for these products are on semi-finished or heavily worn bearings operating at slow speeds in lumber, mining, road building and rock crushing equipment; on skids, track curves, wagon wheels and similar type installations.

Calcium resinate soap base greases or "Cold Sett", as they are often called, are somewhat similar to the cup greases of Group No. 1 in properties, but differ radically in their method of manufacture, as explained in the first article of this series.

These products have a buttery texture, may contain up to 5 per cent of water and have dropping points of approximately 275°F. Although their dropping points are quite high, they should not be used at temperatures much above the boiling point of water for above this point some frothing will naturally occur. Since axle greases are not designed for applications where heat resistance is a factor or where the grease will remain for long periods of time, extreme oxidation resistance is not necessary.

Group No. 3—Sodium Soap Base Grease—General

Sodium soap base greases are normally of two types, (1) those drawn from the kettle at temperatures below the melting point of the grease and (2) those drawn in a molten stage. The characteristics and uses of the latter are so radically different from the first that they are discussed as a separate group. (See Group No. 4—Sodium Soap Base—Brick Grease.)

Sodium soap base greases drawn from the kettle below their melting point have in the past usually been of a fibrous nature but recent research has resulted in the development of greases which are of smoother texture, approaching that of cup greases. Some manufacturers obtain this smoother texture by milling a fibrous grease but this only produces a temporary effect since the milled grease, after heat subjection for example in a bearing, tends to revert to the original fibrous texture. On the other hand, by proper choice of ingredients, smooth textured greases can be drawn directly from the kettle without necessity of milling and these greases, after repeated heat subjection, still remain smooth.

The matter of application determines whether a long fibered, short-fibered or smooth textured grease should be used. For chassis lubrication and universal joints the long fibered products have been found particularly advantageous. For anti-friction bearings, on the other hand, the long fibered greases are prone to leak out due to the pumping action of the rotating parts forcing the grease out of the bearing housing.

One of the most important properties of greases in this group is their excellent heat resistance. They have dropping points ranging up to about 450°F., and are usually made of excellent raw materials so that they have good resistance to oxidation, a property which is often further improved by incorporating oxidation inhibitors. As a result greases of this type enjoy wide popularity in high temperature in-

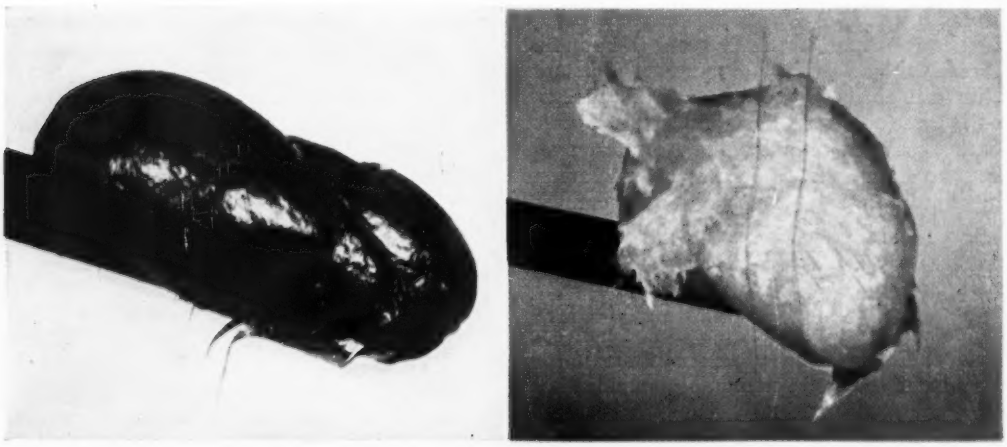


Figure 6—Group No. 3—Sodium soap base grease. At the left is a medium length fiber No. 3 NLGI grade product containing a steam refined cylinder oil and at the right is a long fibered product of No. 3 grade made with an oil having an approximate viscosity of 300 seconds at 100°F. Say. Univ.

stallations. In fact they can be used for short durations at temperatures above their dropping point without harm, providing of course, the housing will retain the fluid grease.

Another advantage of sodium soap base greases is their anti-rust properties in the presence of water. These greases have the ability of absorbing a certain amount of water with the result that water which seeps into a bearing due to condensation or contamination is immediately absorbed into the grease. Water resistant soap base greases on the other hand do not absorb moisture, therefore, with such products globules of water may collect on the metal surfaces, resulting in rusting.

Sodium soap is somewhat soluble in water; therefore, greases made from this base are water susceptible. Generally speaking the degree of water susceptibility of all greases made from water soluble soaps is controlled by the type of fat used, soap concentration and oil viscosity, for the more saturated the fat, the lower the soap content and the higher the viscosity of the oil, the less susceptible the grease will be to water.

Even though greases in this group are somewhat water susceptible, those made with a high viscosity oil have been found to be superior to greases in Group I as a lubricant for the chassis of automotive equipment. This is due primarily to the fact that these greases have the ability to adhere and even when emulsified with water still offer protection to the bearings.

Sodium soap base greases are used for the lubrication of ball and roller bearings over a wide range of speeds and temperatures. At high speeds greases of this type incorporating small amounts of calcium soap are often used because such products have certain desirable properties as will be discussed later. Sodium soap base greases are particularly suitable for wheel bearings, universal joints, and spring shackles of automotive equipment; for plain bearings, and centralized pressure lubricating systems. Lighter grades of greases in this group are often recommended for the lubrication of gears where ordinary oil type gear lubricants would be too fluid and leak out.

Group No. 4—Sodium Soap Base—Brick Grease

Brick greases are used on plain bearings so designed that a cake of grease can be applied directly to the revolving journal. In many instances, notably journals on railroad locomotives, the cake is pressed against a perforated screen which is curved to fit the contour of the journal.

The term "brick grease" is derived from the fact that these greases are drawn from manufacturing kettles in a molten state, and they "set up" on cooling into hard, firm cakes. They usually contain from 30 to 50% soap and a high viscosity oil, although

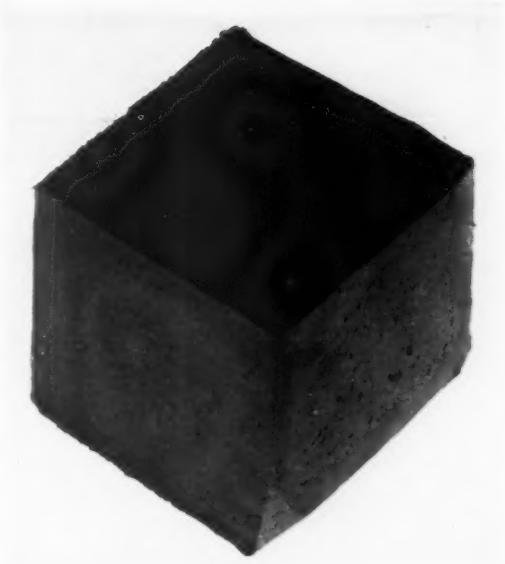


Figure 7—Group No. 4—Sodium soap base—brick grease. Note the oil pockets which assist in keeping journals well lubricated.

lower viscosity oils may be incorporated providing the resultant grease is used on bearing which are not of the heavy duty type. Dropping points of brick greases range up to 450°F. and as a rule these greases are very heat resistant.

Consideration of the properties and use of brick greases emphasize the fact that the results of physical properties, such as dropping point and penetration, are not necessarily indicative of high temperature or heavy duty performance and that other inherent properties of a grease very often are more important.

For example, consider the driving journals on locomotives. On these bearings are concentrated most of the weight of the locomotive and in addition the bearings are subjected to very high rubbing speeds. In considering the desired properties of a brick grease to withstand the conditions existing in a driving journal it has often been wrongly thought that a high dropping point alone was an indication of ability of the grease to stay in the cellar without feeding out. A product may have a very high dropping point, yet due to its peculiar structure and texture, it might show excessive consumption. As a case in point, one product with a high dropping point of 458°F. was found to give a consumption approximately three times greater than one having a dropping point of 435°F., the oil incorporated in the grease in each case having the same viscosity.

Excessive hardness, once thought a necessary property to increase heat resistance, is not desirable since such greases at ordinary temperatures are too hard to feed out properly. The ideal driving journal grease is one which is as soft as possible at normal temperatures yet retains its body at higher temper-

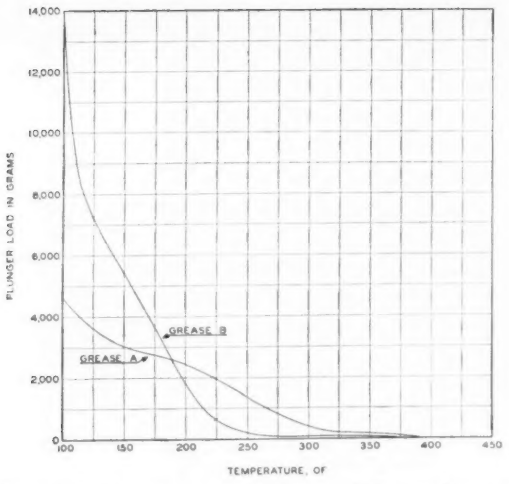


Figure 8—Consistency tests on Driving Journal Compounds over a wide temperature range as measured on the McJunkin Machine.

atures and at the same time reduces frictional heat to a minimum. As an example of this point, consider Figure 8, Page 88 which illustrates results of tests on two commercial driving journal compounds made on the McJunkin Machine. In this test a perforated disk is pushed through a sample of grease at constant speed while the temperature is being raised at a constant rate. A record of the pressure required to push the plunger through the grease is an indication of its hardness over the temperature range tested. Both greases have the same approximate dropping points, namely, 440°F., but Grease B is at least twice as hard as Grease A at room temperature. As the temperature is increased Grease B softens very rapidly until at about 190°F. It actually becomes softer than Grease A, and at 210°F. Grease A is twice as hard as Grease B. Grease A is a much more desirable grease since it is softer at room temperature and will start lubricating instantly yet it more nearly retains its consistency as the temperature is increased and at operating temperatures this grease will show a minimum consumption.

Group No. 5—Aluminum Soap Base Greases

Aluminum soap base greases are characterized by their beautiful transparent color, smooth buttery texture, and their ability to resist the action of water.

One of the outstanding properties of these greases is their ability to withstand centrifugal action, and as a result these greases have found acceptance where such a property is desired, for example, on the hubs of aircraft propellers, and in certain applications of the textile industry.

Their dropping points are generally low, about 200° F. but the dropping point in this case has little bearing on the uses to which aluminum soap base greases can be put. Changes in temperature, i.e., rapid heating and cooling, have a marked effect on the texture of these greases. If cooled slowly to room temperature they may become very soft and stringy or if cooled too rapidly they become hard and crumbly. These changes in texture limit the use of aluminum soap greases due to the fact that one is never quite sure what the condition of the grease will be after it has been in use for a comparatively short time, particularly on anti-friction bearings.

There are certain applications where due to their water insolubility and adhesiveness these greases are acceptable. They have been used as a chassis lubricant on cars; on oscillating surfaces; gears, chains, cams, etc. of textile machinery; as a substitute for cup grease, and other similar applications.

Aluminum soap base greases have never been as widely accepted as sodium and calcium base greases. They can be used in a variety of applications but for general run of the mill uses, other greases have proven more satisfactory primarily because of the effect of temperature on the texture of these products.

Group No. 6—Lithium Soap Base Grease

Lithium soap base greases are comparative newcomers in the field of lubricants and have been used primarily in military operations where conditions of service are necessarily unusual and not comparable with peace-time conditions. In general, these greases have high melting points similar to the sodium soap base greases, and, in addition, are relatively water resistant. When inhibited, they have good oxidation resistant properties similar to the sodium or sodium-calcium mixed base greases.

At the present time, greases in this group are used for specialty applications primarily because more development work must be completed before they become generally available. Their high cost and the

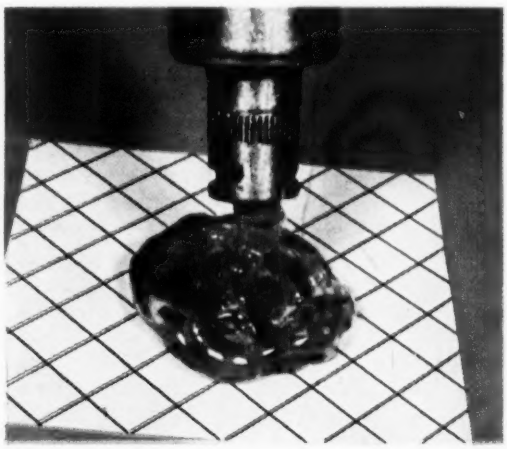


Figure 9—Group No. 5—Aluminum soap base grease characterized by its transparency and smooth texture.

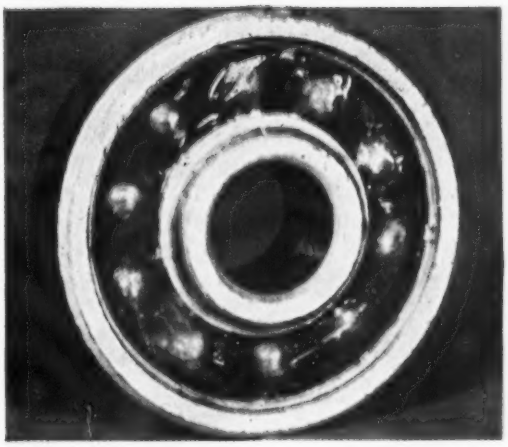


Figure 10—Group No. 6—Lithium soap base grease designed for ultra-low temperature lubrication shown on a #204 bearing.

fact that in the past they worked down badly has been a handicap to date, although recent research has resulted in the development of greases having marked resistance to working down or liquifying at high rates of shear. Although these products have high melting points similar to the sodium or sodium-calcium mixed base greases, they have not been in service long enough to determine their value in high temperature applications.

Group No. 7—Mixed Base Greases

Mixed base greases are made in an endeavor to embody the merits of more than one type of grease and eliminate the defects of a single base grease.

The most outstanding example of this type of product is sodium-calcium soap base grease extensively used on ball and roller bearings. Other examples are calcium-lead, and aluminum soap in combination with others.

Sodium-calcium soap base greases are ideal anti-friction bearing lubricants. The presence of calcium soap modifies the fibrous nature of sodium soap base grease with the result that sodium-calcium base greases are almost buttery in texture. They offer a low resistance to working or shear, both on starting up and during continuous operation. Temperature has a minimum effect on this type of grease and some grades are manufactured which will lubricate through a temperature range of −40°F. to +250°F. or higher. Since most greases of this type are designed for use where relubrication is infrequent or temperatures are high, oxidation inhibitors are often incorporated. These lubricants are excellent for high speed bearings and can be used on anti-friction bearings at speeds up to 20,000 RPM, or higher. These properties make sodium-calcium soap base greases the most versatile of all greases on the market today, thus accounting for their tremendous popularity.

TEMPERATURE – A FACTOR IN APPLICATION

One of the most critical factors to be considered in the choice of a suitable grease for a specific application is the temperature range over which the grease will operate. The foregoing comments pertaining to the application of the various groups of greases apply to the normal temperature range in which each group functions. Often, however, greases are desired for a specific application which will lubricate at unusually high or low temperatures. In any given group of greases there are certain factors or properties of the various members of that group which makes one specific product more suitable than any other.

High Temperature Lubrication

Greases, in general, with the exception of aluminum soap base greases and water stabilized calcium soap base greases, can be used in continuous operation up to about 225°F. with comparatively good

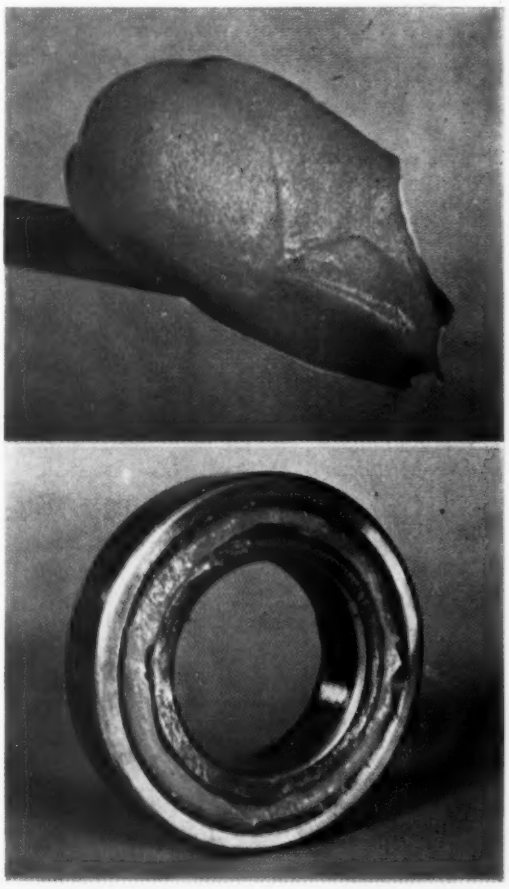


Figure 11—Mixed base grease containing sodium and calcium base soap incorporating an oil having an approximate viscosity of 300 seconds at 100°F. Say. Univ. and designed for anti-friction bearings.

results, but above this temperature special attention must be given to the choice of a lubricant. Heat, speed and pressure are all factors which may cause deterioration of greases and these conditions coupled with other factors often found, such as dust, dirt and steam sometimes make high temperature bearings difficult to lubricate.

A generally accepted rule in chemistry is that rates of reactions are doubled for every 18°F. increase in temperature. Thus, the higher the temperature the more rapidly grease will oxidize. Therefore bearings lubricated with grease and operating at high temperatures must be relubricated at more frequent intervals to flush out the oxidized grease than similar bearings operating at lower temperatures.

As previously brought out, the rate of oxidation for greases is dependent to a great extent upon the quality of ingredients used in their manufacture. Inferior fatty materials used in the manufacture of soap for greases are particularly prone to oxidize at high temperatures. It is more economical to use premium grade products in bearings operating at high temperatures and particularly so in applications where frequent relubrication is not practical.

In selecting a high temperature grease the first consideration is the determination of suitable soap bases. A second and almost as important consideration is the oil constituent of the grease. Well refined oils, resistant to oxidation are obviously desirable. The viscosity of oils used in high temperature greases is dependent upon speed, load and similar conditions in the same manner as such factors affect the choice of an oil for oil lubricated bearings. Usually an oil having a viscosity of 500 seconds at 100°F. Saybolt Universal, or higher is used. However oils having a viscosity below 100 seconds at 100°F. are currently being used in some greases designed to operate at 250°F.

The consistency of greases is an important property to be considered for ease of application, sealing properties, resistance to turning and other similar factors, but the effect of changes in consistency for any given series of greases on the dropping points is surprisingly small. From a practical standpoint this means where a grease has insufficient heat resistance for a specific application little is to be gained by going to a heavier grade in the same series.

Low Temperature Lubrication

Greases offer several advantages over oil in applications where low temperatures are a factor to be considered. This is particularly true at temperatures below the usual pour points for oils. For example, there have been developed for the lubrication of aircraft flying in the stratosphere greases which are pliable at −100°F. whereas, the mineral oil components used in such greases would cease to pour at about −70°F.

Soap has the ability of not only thickening oils throughout a very wide temperature range, thereby greatly extending their application but the apparent viscosity of the resultant mixture is less affected by temperature than is the oil alone. This fact contributes materially to the ability of greases to be plastic at low temperatures and to have sufficient body at elevated temperatures so that consumption and leakage can be controlled.

A popular misconception concerning the factors affecting the choice of a grease for low temperature lubrication is that if a grease is too heavy at low temperatures, a lighter grade in the same series should be used.* Consistency is a factor to be considered in the choice of a low temperature grease, but its importance is not as great as one would expect.

Other properties which have a far more important bearing on low temperature characteristics are:

Viscosity of the oil: The lower the viscosity of the oil, the better the low temperature characteristics of the grease.

Paraffin vs. Naphthene Base Oils: Paraffin base oils are preferable because changes in temperature have less effect on their viscosity than on naphthene base oils. Paraffin base oils having very high pour points are not as desirable as those having lower ones in instances where extremely low temperatures are encountered.

Texture: This property is difficult to classify in that two similar appearing greases may have radically different low temperature characteristics, but in general, smooth, buttery greases are better than fibrous greases.

Strangely enough, the type of soap base may be relatively unimportant. Excellent ultra-low temperature greases can be made from any of the more popular soap bases, however, lithium soap base greases have been used during the war period.

CONCLUSION

The Grease Industry is proud of its contribution to the development of modern machinery for without greases available on the market today it would have been impossible to design many machines with such simplicity and ease of movement. Greases are available which will function under the most adverse conditions and when future developments of industry necessitates the manufacture of other types of products grease technologists are in a position to develop them. At present grease chemists are studying new types of soap bases and fundamental theories of grease lubrication. Even now greases manufactured from soaps made of barium, strontium, magnesium and other metallic bases are being examined in the laboratory, and a few such products have reached the market. The ultimate goal is to develop the fewest number of products which will lubricate bearings under all types of conditions with the least amount of attention.

*Some manufacturers alter the composition of the lightest grades in a given series to give them better low temperature characteristics, in which case, this statement would not apply.

Printed in U.S.A. by
Salley & Collins, Inc.
305 East 45th St.
New York 17, N. Y.

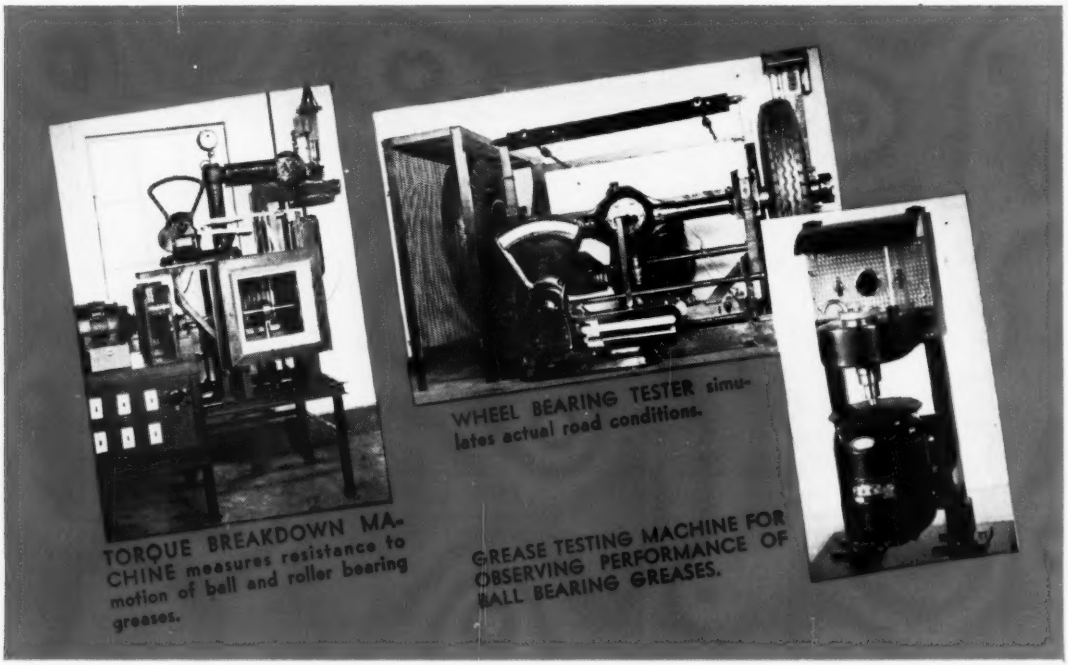
Schedule of Texaco Lubricants Recommended for Ball and Roller Bearings

Temperature	Bearing Size	R.P.M.	Grease-Lubricated Bearings
Below −40° F.	Generally below 6" O.D.	Generally below 1000 rpm.	LOW-TEMP Grease 67 or Regal Starfak No. 1
−40 to 32° F.	Under 6" O.D.	Under 500	Regal Starfak No. 2 or Starfak Grease M
		500-1000	Regal Starfak No. 1 or No. 2 or Starfak Grease M
		Over 1000	Regal Starfak No. 1 or Starfak Grease L
	6" O.D. and over	Under 500	Regal Starfak No. 2 or Starfak Grease M
		500-1000	Regal Starfak No. 2 or Starfak Grease M
		Over 1000	Regal Starfak No. 2 or Starfak Grease M
32° to 150° F.	Under 6" O.D.	Under 500	Regal Starfak No. 2 or Starfak Grease H
		500-1000	Regal Starfak No. 2 or Starfak Grease M
		Over 1000	Regal Starfak No. 2 or Starfak Grease M
	6" O.D. and over	Under 500	Marfak No. 2 H.D.
		500-1000	Regal Starfak No. 2 or Starfak Grease H
		Over 1000	Regal Starfak No. 2 or Starfak Grease M
150° to 200° F.	Under 6" O.D.	Under 500	Marfak No. 2 H.D.
		500-1000	Regal Starfak No. 2 or Starfak Grease H
		Over 1000	Regal Starfak No. 2 or Starfak Grease M
	6" O.D. and over	Under 500	Marfak No. 2 H.D.
		500-1000	Marfak No. 2 H.D.
		Over 1000	Regal Starfak No. 2 or Starfak Grease H
200° to 275° F.	Under 6" O.D.	Under 500	Regal Starfak No. 2
		500-1000	Regal Starfak No. 2
		Over 1000	Regal Starfak No. 2
200° to 350° F.	6" O.D. and over	Under 500	Marfak No. 2 H.D.
		500-1000	Marfak No. 2 H.D.
		Over 1000	Marfak No. 2 H.D.

TEXACO

REG. U.S. PAT. OFF.

THE TEXAS COMPANY


TORQUE BREAKDOWN MACHINE measures resistance to motion of ball and roller bearing greases.
WHEEL BEARING TESTER simulates actual road conditions.
GREASE TESTING MACHINE FOR OBSERVING PERFORMANCE OF BALL BEARING GREASES.

Maintaining and Improving GREASE QUALITY

THE three machines illustrated are typical of the precision instruments developed by The Texas Company for testing greases and anti-friction bearing performance. Test equipment such as this enables Texaco Engineers to control and maintain uniform quality in the production of greases—such as *Texaco Regal Starfak*—and, through research, to assure the improvements in greases necessary to keep pace with ball and roller bearing development.

THE TEXAS COMPANY

THE TEXAS COMPANY • TEXACO PRODUCTS • DIVISION OFFICES

ATLANTA 1, GA. . . . 133 Carnegie Way
BOSTON 17, MASS. . 20 Providence Street
BUFFALO 3, N. Y. . . 14 Lafayette Square
BUTTE, MONT. . . Main Street & Broadway
CHICAGO 4, ILL. . 332 So. Michigan Avenue
DALLAS 2, TEX. . . 2310 So. Lamar Street
DENVER 1, COLO. . . . . 910 16th Street
HOUSTON 1, TEX. . . 720 San Jacinto Street
INDIANAPOLIS 1, IND., 3521 E. Michigan Street
LOS ANGELES 15, CAL. . 929 South Broadway
MINNEAPOLIS 2, MINN. . 300 Baker Bldg.
NEW ORLEANS 6, LA., 919 St. Charles Street
NEW YORK 17, N. Y. . 205 East 42nd Street
NORFOLK 1, VA. . Olney Rd. & Granby St.
SEATTLE 11, WASH. . . 1511 Third Avenue

Texaco Products distributed throughout Canada by McColl-Frontenac Oil Company, Limited, **MONTREAL, CANADA**